Arkwood, Inc., Superfund Site
DRAFT Comments on DRAFT Supplemental Groundwater Tracing Summary Report dated March 2015

Item No.	Reference	EPA Comments for Discussion on May 19	PRP Response
1.	Supplemental Groundwater Tracing Summary Report General	The maps and figures used to identify the site and important sampling locations can be improved. Generation of water-level maps (water table and potentiometric) would help with identifying pathways. A base with topographic contours would help map potential discharge locations. All receptors (other adjacent withdrawal wells) should be identified on maps. Ambient and injection maps would identify changes in flow patterns.	
2.	Supplemental Groundwater Tracing Summary Report General	Less than 50% of the dye was recovered/detected at sample locations. It is speculative to assume that an equivalent amount of dye or greater was retained in non-mobile volume of the rock. Another scenario is that all pathways were not determined and some deep underflow occurs.	
3.	Supplemental Groundwater Tracing Summary Report General	Another approach to assess mobile vs. non-mobile porosity would be to perform injection-extraction tests where the extraction well is the primary sample location. Ambient tracer tests can help define likely pathways typically encountered at the site for most of the time.	
4.	Supplemental Groundwater Tracing Summary Report Section 1.1, Purpose and Scope of Study Page 3	EPA agrees with investigating contaminant transport from the former sinkhole location; however, it appears there were two main areas where waste management activities occurred, (1) in the former sinkhole location, and (2) on the north side of the property where creosote and pentachlorophenol (PCP) or non-aqueous phase liquids were managed. To ensure a comprehensive understanding of	

		contaminant transport, it would be advantageous to consider additional tracer releases in the former wood storage and process areas where a significant release of waste residuals is known to have occurred (the trolley and treatment area). For example, the RI reported wells MW-4, -5, -8, and -10 were contaminated. These wells are just north of the site in the low-lying area adjacent to the railroad tracks. The tracer test conducted in 1991 was initiated in the southeastern area of the site and results indicate no dye was measured in New Cricket Spring (sample location #17). However, dye was measured in numerous locations on the north side of the site, suggesting that ground water located in the southeast area of the site moved to the north, not to the west towards New Cricket Spring. This information underscores the importance of developing a better understanding of contaminant transport in other process areas, in addition to the former sinkhole.	
5.	Supplemental Groundwater Tracing Summary Report Section 1.3 Page 4	What is or is there any preferred bedding direction in the rock?	
6.	Supplemental Groundwater Tracing Summary Report Section 1.3 Hydrogeologic Setting	The report states, "The semi-quantitative dye tracing investigation discussed in this report provides a valuable on-Site measurement of the percent of mobile porosity existing in the most impacted portion of the shallow epikarstic zone aquifer at the Arkwood Site." The report does not provide the procedures used to	

	Page 4.	estimate the percent mobile porosity based on the results of the tracer tests. The report should be revised to include this information.	
7.	Supplemental Groundwater Tracing Summary Report Section 1.4 Previous Groundwater Tracing Study Page 5	The report states that one trace was introduced at the "woodchip pile" at the southeast corner of the site, and that "The 1991 tracing demonstrated that the Site was underlain by a groundwater divide. Groundwater from the southeastern portion of the Site discharges to the Walnut Creek topographic basin and groundwater from the northwestern portion of the Site discharges to the Cricket Creek topographic basin." This is an important aspect of the tracer study, and it relates to the overall feasibility of the New Cricket Spring to fully capture contaminated ground water at the Arkwood site. The ground water flow divide conceptual model is supported by Figure I-7 of Appendix D (Revised Final Tracer Workplan), where it is evident that ground water in the eastern portion of the site flows approximately to the north (i.e., as a result of the 1991 dye tracer study), and the results of the 2014 tracer study, which suggest that ground water in the central portion of the site, near the sinkhole, flows generally to the west. Further support of this conceptual model was provided by data and information in the Remedial Investigation Report in 1990. Given that the water table data are available from a limited number of wells; there is significant topographic relief across the study area; and, several hydrogeologic/lithologic zones exist at the site, judicious data interpretation of the ground water levels and flow direction should be exercised. Water table isocontours indicate that the on-site ground	

		water flow direction is complex and involves multi-directional flow (Figures 4-36a, b, and c). Also, the mapped elevations of the water table indicate a discontinuous water table (page 4-40). The multi-directional ground water flow is consistent with a "flow-divide" that occurs in all three figures and is also consistent with a perched aquifer condition. Installation of several wells during the previous ground water investigation occurred in low permeable media. A layer of low permeability is one of the conditions that is typically found in a "perched aquifer." Wells screened in this zone are also prone to be pumped dry. Assuming this hydrologic conceptualization is accurate, flow directions are projected to be time-dependent as they reflect periodic precipitation inputs. Periodic inputs of PCP contaminated ground water may also result from rainfall events. The projected ground water flow directions in the area of MW-9 and MW-11 (across the tracks) suggest that these wells are further upgradient, that flow is northward towards the railroad tracks, and that this explains the lack of contamination in the MW-9 and –MW-11 area. Multiple lines of evidence are consistent with a ground water flow divide hydrologic conceptual model. Therefore, the on-site multi-directional contaminated ground water flow directions are unlikely to be captured by the New Cricket Spring located off-site on the west side of the facility. Given this preliminary assessment of the data and information, it appears unlikely that capture of all the contaminated ground water by New Cricket Spring has been attained. It would be worthwhile to re-evaluate the ability of the New Cricket Spring ground water treatment system to fully capture all of the contaminated ground water	

		emanating from the area encompassed by the Arkwood site.	
8.	Supplemental Groundwater Tracing Summary Report Section 2.2.1 Types of Samples Page 8	The report states, "Composite water samples were collected to permit a mass balance calculation for each tracer dye. This information permits a measurement of the percent of mobile porosity in the portion of the epikarstic aquifer lying between the former sinkhole and New Cricket Spring." The report should specify what calculations were used to estimate "mobile porosity."	
9.	Supplemental Groundwater Tracing Summary Report Table 5 Page 9	Please label the injection wells.	
10.	Supplemental Groundwater Tracing Summary Report Figure 1 Page 10	City water location #18 is missing on the map. Please label the springs.	
11.	Supplemental Groundwater Tracing Summary Report Table 6 Page 11	How can Well B be dry on 11/17/14 when water was injected into the well for tests? Are these pre-test values? Was there a reason contemporaneous water levels were not measured during test?	

12.	Supplemental Groundwater Tracing Summary Report Section 2.3 Laboratory Analyses Page 12 Appendix A Page A-7	The report states, "Activated carbon samples were rinsed under a relatively strong jet of water, eluted in a standard eluting solution. Water samples were pH adjusted to raise the pH of the water to 9.5 or higher." Appendix A indicates the elution solution is typically comprised of an alcohol, water, and a strong basic solution such as aqueous ammonia and/or potassium hydroxide. It is recommended that information be provided regarding the extent to which a mass balance could be achieved in the complete removal of the dyes from the carbon as a control sample.	
13.	Supplemental Groundwater Tracing Summary Report Section 2.4 Page 13	Please provide a weir rating table.	
14.	Supplemental Groundwater Tracing Summary Report Section 3, Study Results Page 14	Please explain how the dye extracted from the activated carbon was extrapolated back to ground water concentrations.	
15.	Supplemental Groundwater Tracing Summary Report Table 8	A runoff rate per area would be helpful to assess whether underflow is occurring at the weir.	

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16.	Supplemental Groundwater Tracing Summary Report Tables 9 through 11 Pages 16 through 19	Including travel times in the table would be helpful.	
17.	Supplemental Groundwater Tracing Summary Report Section 3.2.1 Trace 14-01: Former Sinkhole Area Well A. Fluorescein Trace. Page 16	The presence of fluorescein dye in the Cricket Pond suggests that the New Cricket Spring did not capture all of the tracer-amended ground water that left the Arkwood site. Please elaborate on this matter.	
18.	Supplemental Groundwater Tracing Summary Report Tables 10 through 12 Pages 17-20	The sampling period begins before the tracer introduction. Does this mean the initial concentration of the dye is a background value?	

19.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 First paragraph Appendix C	The report indicates that the mass balance calculations showing the incremental mass of dye recovered in New Cricket Spring (i.e., flow × concentration × time) are included in Table C-3 of Appendix C. This information was not included in Appendix C. Table C-1 is also missing from Appendix C. Please provide the missing information.	
20.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 Second paragraph	The report states, "The technical literature suggests that dye traces from sinkholes to springs are typically characterized by 20 to 50% of the introduced dye being detected at the receiving spring (Aley1997). The detection percentages from this study are within the reported range." The potential array of possible testing conditions that could occur for a specific tracer test is broad and dependent on many site variables. Therefore, it does not seem prudent that the range of recovery reported (20-50%) should serve as a quality assurance or quality control metric.	
21.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 Third paragraph	The report states, "The detection percents for the two dye traces (45% for fluorescein and 38% for rhodamine WT) provide a measure of mobile porosity in the most contaminated portion of the groundwater system at the Arkwood Site." Please clarify how the mobile porosity was calculated from the dye tracer test results.	

22.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22 Third paragraph	The report indicates the dye that was not recovered was detained within the non-mobile portion of the epikarstic aquifer. An additional tracer fate mechanism that was not investigated or discussed involves the transport of the tracer beyond the capture zone of the New Cricket Spring. Specifically, under this condition the tracers would bypass the capture zone of the spring. Please clarify why it was inferred that the unrecovered dye did not simply bypass the New Cricket Spring.	
23.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 22	The report seems to conclude that all pathways have been identified and, therefore, the amount of dye recovered is a function of mobile and immobile porosity, but this is not stated or supported.	
24.	Supplemental Groundwater Tracing Summary Report Section 3.3.2 Mass Balance Calculations Page 23 Appendix B Table B-1	It was reported that the difference between the travel times of the fluorescein and the Rhodamine WT dyes was due to the potential sorption mechanisms of the latter dye. Fluorescein and Rhodamine WT dyes were injected into wells A and B, respectively (both screened 15-25 ft bgs). However, fluorescein was not detected in well B, and was essentially non-detect or very low in 7 other wells nearby (Wells C, D, G, H, I J, and K) (Appendix B, Table B-1), and the Rhodamine WT dye injected into well B was not detected or was detected at very low concentrations in wells D, E, H, I, and J (Appendix B, Table B-1). Injection of these dyes was followed by the injection of a large volume of clean water that helped to distribute the tracer beyond the sand packs in these wells. These results suggest heterogeneous ground	

		water flow paths exist in the subsurface within a relatively small plan view area. Given the known heterogeneity of the subsurface, it is reasonable to assume that differences in dye recovery could also be attributed to different flow paths which could lead to differences in the degree of dye recovery in (and bypassing of) the New Cricket Spring.	
25.	Supplemental Groundwater Tracing Summary Report Section 4 Summary and Conclusions Item 1 Page 24	The report states that "groundwater from the former sinkhole area on-Site only discharges from New Cricket Spring." The evidence from the tracer study does support the idea that the majority of groundwater is discharged from New Cricket Spring; however, low levels of dye were detected in Cricket Pond which indicates that some groundwater is following other pathways. Therefore, the absolute of New Cricket Spring being the only discharge point is not supported. The evidence does support the statement that a majority of the groundwater from the former sinkhole discharges from New Cricket Spring. The movement of a dye dissolved in water will differ from the movement of non-aqueous phase liquids through the epikarst and karst zones. Dense non-aqueous phase liquids could have different groundwater pathways than the dyes dissolved in aqueous or water phase.	
26.	Supplemental Groundwater Tracing Summary Report Section 4 Summary and Conclusions	One of the conclusions from the study is presented as: "1. Groundwater from the former sinkhole area on-site only discharges from New Cricket Spring. Groundwater from this area does not discharge from Cricket Spring, the southeast end of the railroad tunnel, or in the Walnut Creek valley." EPA would agree with this conclusion based on the mean flow discharge rates from New Cricket Spring	

	Item 1 Page 24	recorded during the study period from November 1, 2014, to January 5, 2015. However, at a certain (unknown) threshold water level in the epikarst formation (and consequential high flow rate from New Cricket Spring), the mobile porosity will exceed the elevation of the groundwater divide on the site, with potential contaminant discharge to the adjacent railroad tunnel spring, as has previously occurred. Additional investigative activities should be completed to account for this issue.	
27.	Supplemental Groundwater Tracing Summary Report Section 4, Summary and Conclusions Item 6 Page 25	The report indicates the fate of the dye is either: (1) that it was captured by the New Cricket Spring; or, (2) that it was "detained in the non-mobile porosity of the epikarstic aquifer." Dye transport into immobile pores could take months and years. But in this case, the tracer test lasted 7 weeks and peaked at the New Cricket Spring within 8-16 hours of injection allowing limited time for diffusive transport. No data or information was provided to suggest that the unrecovered dye could have bypassed the New Cricket Spring. It appears that the hydrologic conceptual model suggested in this report is that all the ground water associated with the western portion of the site, and possibly all of the ground water underlying the site, is captured by the New Cricket Spring. This does not seem to be justified. Based on the physical properties of PCP (density, solubility in water, and increased water solubility with increased pH in karst terrain), it appears that a large volume of this contaminant may be stored within the epikarstic aquifer, and it would be likely to be discharged in response to fluctuating groundwater levels indefinitely.	

		The detections of low levels of introduced dyes in Cricket Pond indicates that other pathways from the sinkhole area are possible. Due to various lines of evidence, a direct conduit between the sinkhole and the New Cricket Spring has been established. At the outset of the tracer test, it was unclear whether the spring would fully capture the entire mass of tracer injected into the sinkhole area. Based on the results of these tracer tests, it does not appear prudent to conclude that the New Cricket Spring captures all the contaminated ground water passing from the sinkhole area. It would be informative to inject tracer dye where waste management activities were tested, not just the sinkhole area. As it is, conclusions are not possible regarding the extent to which New Cricket Spring captures contaminated ground water passing through other areas of the site. A more extensive investigation should be planned to consider what happens when the flow rates are significantly higher than those tested in this study.	
28.	Supplemental Groundwater Tracing Summary Report Section 4, Summary and Conclusions Item 6 Page 25	A ratio of 20% to 80% mobile to non-mobile porosity means that the karst aquifer is 100 % made of voids over the whole site. Instead of concluding 80% of total porosity is non-mobile, it is more likely that some percentage of the 80% is made up of pores not readily accessible to transport.	

29.	Supplemental Groundwater Tracing Summary Report Appendix B	Tables B-2 and B-3 are missing.	